File No. 31727-2019

TORYS LLP

UNITED STATES

Title: POWER ACTUATOR FOR AUTOMOTIVE CLOSURE LATCH

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FIELD OF THE INVENTION

[0001] This invention generally relates to power actuators for vehicle latches, as for example to a power actuator for releasing a trunk latch or a power actuator for moving a lock lever between a locking and unlocking position.

BACKGROUND OF THE INVENTION

[0002] Cost is an important factor for manufacturing vehicle accessories such as motorized latch release devices. The number of parts which compose a power actuator has a bearing on the cost of the product. Heretofore, known power actuators for automotive closure latches have more parts, and thus likely higher cost, than the present invention.

SUMMARY OF THE INVENTION

[0003] A power actuator for automotive closure latches according to the preferred embodiment of the invention has a reduced number of components in comparison to comparable devices currently on the market.

[0004] According to one embodiment of the invention, a power actuator is provided which includes a housing; an electric motor mounted in the housing; a worm operatively coupled to the motor for driving rotation of the worm about an axis in a first rotational direction; a worm gear, in meshing engagement with the worm, and being mounted in the housing for rotation about an axis substantially orthogonal to the worm axis; a camshaft mounted on the worm gear and having a rotation axis coincident with the gear axis, the camshaft having a distal end; and an output arm affixed at the distal end of the camshaft.

[0005] The power actuator may be employed as a latch release device. According to this embodiment, the latch release device includes a housing; an electric motor mounted in the housing; a worm operatively coupled to the motor for driving rotation of the worm about an axis in a first rotational direction; a worm gear, in meshing engagement with the worm, and being mounted in the housing for rotation about an axis substantially orthogonal to

the worm axis; a camshaft mounted on the worm gear and having a rotation axis coincident with the gear axis, the camshaft having a distal end extending to the exterior of the housing; and a cam affixed at the exterior end of the camshaft, having a surface for engaging a said latch to move the latch from a closed position to a release position as the gear rotates in a first direction from a first position to a second position when driven by the motor.

[0006] In a preferred embodiment of the latch release device, the worm has a small diameter worm, efficient for the overall size of the device. The combination of an output cam with a gear reduction stage results in high overall force output as well.

[0007] In the preferred embodiment of the latch release device, the worm gear is biased against the rotation from the first position to the second position. The ability to implement a biasing return spring provides repeatable uni-directional force output, and without such a spring, bi-directional torque/force output.

[0008] In a particular embodiment, the device includes electrically conductive contacts embedded into the housing as the housing is molded from plastic resin, to be in electrical contact with the motor and the same time extending to the exterior of the housing for connection to an electric power supply. The integration of an electrical connector is another example how further functionality without additional components or complexity can be obtained by means of the invention described herein.

[0009] The housing of the latch release device can include an injection-molded closure plate, wherein a hollow portion of the housing and the plate have opposing walls shaped to abut a housing of the motor when the hollow portion and the plate are secured together, and the plate further includes protrusions which extend into the housing interior to abut sides of the motor housing to preclude movement therepast.

[0010] In another preferred aspect, the closure plate and housing include a plurality of holes in communication with each other and located to permit simultaneous fastening of the housing and closure plate together and fastening of the device adjacent a latch with the cam in operable proximity

thereto. This arrangement permits utilization of the same fasteners which mount the unit to a host latch or mechanism to also bind the housing components of the device together. The preferred embodiment thus provides a highly versatile, customizable, compact, low-cost mechanism for power release or locking.

BRIEF DESCRIPTION OF THE DRAWINGS

[0011] Detailed embodiments of the invention are described below with reference to the accompanying drawings in which:

[0012] Figure 1a is a perspective view of a motorized latch release device of the present invention installed on an automobile, in a closed position;

[0013] Figure 1b is similar to Figure 1a in which the motorized latch release device is in an open position;

[0014] Figure 2 is a partially exploded view taken from a vantage point similar to that of the previous figures, having the cover plate of the latch release device removed and partially exploded to reveal the electric motor and worm gear arrangement of the mechanism;

[0015] Figure 3 is a more fully exploded view taken from a vantage point similar to that of the previous figures, to reveal the inner housing, worm wheel and spring for biasing the worm wheel towards the closed position, and the seating area for the motor;

[0016] Figure 4 is a plan type of view of the housing, spring and worm wheel with the worm wheel in the closed position;

[0017] Figure 5 is similar to Figure 4, but with the worm wheel fully rotated into the open position shown in Figure 1;

[0018] Figure 6 is a perspective view of the exterior of the housing opposite of that shown in Figure 1;

[0019] Figure 7 is perspective view from a vantage point similar to that of Figure 6, partially exploded to show the motor and cover plate;

[0020] Figure 8 is a top plan view of the device, as oriented in Figure 1;

[0021] Figure 9 is a bottom plan view of the device, as oriented in Figure 1;

[0022] Figure 10 is a right end view elevation of the device, as oriented in Figure 1;

[0023] Figure 11 is a left end view elevation of the device, as oriented in Figure 1;

[0024] Figure 12 is a rear elevation of the device, as oriented in Figure 1;

[0025] Figure 13 is a plan view of the worm wheel, as viewed from the left of Figure 7; and

[0026] Figure 14 is a sectional elevation of the worm wheel showing the cam installed therewith.

DETAILED DESCRIPTION OF THE INVENTION

[0027] Turning to the drawings, a motorized latch release device **20** of the present invention is shown generally in Figures 1a and 1b. In the figures, the device is shown installed on an automobile to permit remote-controlled trunk release by a driver. As illustrated in Figure 1a, the trunk is in the closed and locked position. Latch **22**, part of a conventional trunk locking mechanism, is biased in the clockwise direction. Generally speaking, device **20** operates through rotation of an output cam **28** from a closed position shown in Figure 1a to an open position shown in Figure 1b. This counterclockwise rotation (as viewed in Figures 1a and 1b) forces latch **22** rightward from its closed position into a release position, as illustrated by the latch positioned in Figure 1b. The output cam **28** automatically rotates back to the closed position of Figure 1a after reaching the fully open position. A detailed description of device **20** and its operation is given below.

[0028] As shown in Figures 2 and 3, the device includes a hollow housing **30** and a closure plate **32**. Each of these members is injection-molded as single piece of plastic in a one-step process. Integrally molded as part of the housing and affixed within the plastic are electrical connectors, described further below, for connecting an electrical motor **34** of the device to an external power supply. The housing and closure are composed of a suitable plastic, in this case a glass and mineral-reinforced nylon resin. The polymers are generally selected for high strength and stiffness, dimensional stability and resistance to temperature extremes.

[0029] As can be seen in Figures 2 and 3, the electric motor **34** includes an output shaft **36** which drives a worm **38** mounted to the external end of the

shaft. The device includes a worm gear **40** in meshing engagement with the worm, a helical spring **42**, and a cam shaft **44** upon which the output cam **28** is mounted. As described in greater detail below, these components are arranged such that the spring biases the worm gear, and hence the output cam, in the counterclockwise direction (as viewed in Figures 1a to 3), towards the closed position. The motor operates via the worm to drive the worm gear in the clockwise direction, i.e., towards the open position shown in Figure 1b.

[0030] Electric motor **34** is a high-torque output, low cogging torque 200-series motor with integrated thermal protection, EMC protection and a knurled shaft. Such motors are available, for example, from Mabuchi Motor Co., Ltd. or Johnson Electric North American, Inc. The motor is mounted in a fixed position within the housing, being held in place by positive abutment with surfaces of the housing and closure plate. A cylindrical stub **48** (see Fig. 7) of the motor is seated against a concave surface **46** of the housing. The motor housing abuts directly against first and second surfaces **50**, **52**. On the inside of closure plate **32** are two rows of triangular protrusions **54** having facing surfaces **56** located and oriented so as to, with inner surface area **58** of the plate, abut against the motor housing. Cylindrical stub **60** is received between upstanding members **62**, **64** of the inner housing of the device, the side surfaces of each member being in abutment to help hold the shaft end of the motor from moving to the right or left, as oriented in Figure 1. The motor includes first and second openings **66**, **68** having electrical terminals disposed therein. Contact posts **70**, **72** are molded into the housing and received within the openings **66**, **68** of the motor each in abutting electrical contact with a terminal of the motor.

[0031] The housing includes a socket **74** having first and second prongs **75a**, **75b** molded externally as part of the rear (as oriented in Figure 1) of the housing. Each of the prongs is electrically connected by an embedded conductor to posts **70**, **72**. Preferably, the socket and prongs are designed to receive a standard plug for supplying electrical power to the motor of the latch release device. However, any suitable form of electrical connector will suffice.

[0032] Turning back to the drive mechanism for the device, the drive end of the shaft **36** extends about 1.5 cm beyond the end of cylinder **60** in which it is suitably journaled. The free end of the shaft has knurled ridges (not illustrated), parallel to the lengthwise axis of the shaft, pressed into it for a length of about 7 mm. The worm **38** is tubular, having an inner diameter slightly less than the outer diameter of shaft **36** so that receipt of the worm onto the shaft results in a snug fit sufficiently tight for the expected life of the device. The ridges on the shaft are deformed radially inward slightly during assembly of the worm onto the shaft and the ridges help to ensure that the worm is rigidly affixed to the shaft so as not to rotate with respect to the shaft during operation of the device.

[0033] Worm gear **40** is preferably injection molded in a single step of a homopolymer acetal selected for its low friction, high wear resistance and dimensional stability properties. Alternative materials are possible. The gear is molded to include a tubular mounting shaft **80** (see Fig. 7). The shaft **80** is received into the open end of a cylindrical mount **82** that is integrally molded in the housing **30**. Shaft **80** has an external diameter of about 1 cm. The diameter of the shaft **80** and the internal diameter of the cylindrical mount **82** are closely dimensioned to each other so that there is very little play between the two pieces, but at the same time the worm gear is free to rotate with respect to the cylindrical mount **82**. The abutting surfaces are very smooth, of circular cross-section, and present minimal frictional resistance to rotational movement of the gear about the central axis of the shafts.

[0034] In the illustrated embodiment the outer diameter of worm gear **40** is about 2.7 cm, and the width of the wheel rim, i.e., the tooth bearing portion of the wheel, is about 1.1 cm, with the total height of wheel shaft **80** being about 1.6 cm. A stop **84** is molded as part of the worm gear. The stop **84** protrudes from the toothed rim a distance of about 4 mm and extends around the circumference of the rim a distance of about 45 degrees. This stop can be omitted in the case that full 360 degree output rotation is desired. A stop **86**, molded as part of the housing, is radially spaced from the center of mount **82** a slightly smaller distance than the radial distance between worm gear stop

84 and the center of shaft **80**. Housing stop **86** and wheel stop **84** together govern the rotational (angular) distance that the worm wheel is permitted to travel between the closed position (Figure 1a) and the open position (Figure 1b), the rotational distance being about 270°. The length of the arc on which housing stop **86** lies is about 45° and the length of the arc on which the worm wheel stop **84** lies is about 45° so that together the two stops together extend about 90° along the common circle on which they together lie. When worm gear **40** is properly mounted and occupying the closed position, abutment surface **90** of the gear stop and abutment surface **92** of the housing stop abut each other to preclude clockwise rotation of the gear. When the gear is rotated counterclockwise to the extreme open position (see Figure 1b) abutment surfaces **94** and **96** of the gear stop and housing stop, respectively, come into abutment with each other so as to preclude further counterclockwise movement of the gear. Because the combined distance of the two stops is 90° of the common circle on which the two stops lie, the rotation of the gear between the closed position and the open position totals 270°. As will be seen further below this is the rotational (angular) distance traveled by cam **28** in operation of the device in releasing the latch.

[0035] Worm gear **40** is biased towards the closed position by the helical spring **42**. Spring **42** is installed within the generally toroidal space located between inner surface **98** of wheel rim, the outer surface of gear shaft **80** and inner surface **100** of gear wall **102**. Located within the toroidal space is a protrusion **104** which stands out from the gear wall and serves as a catch for hooked end **106** of the spring. Protrusion **104** includes overhang **108**. By precluding axial movement of the hooked portion of the spring (as in the direction parallel to the central axis of the wheel and away from inner wall **102**), overhang **108** aids in the installation of the spring during assembly of the device, and helps to ensure that hook **106** of the spring does not slip past the catch during operation of the device. Spring end **110** is in the shape of a hook to latch onto housing surface **96**. It is noted here that gear stop **84** is generally radially spaced outwardly of spring **42**, but that hook **110** protrudes radially outwardly from the remainder of the spring so as to latch onto surface

96, which is itself radially located to abut surface **94** of the stop of the wheel. Clearance for travel of stop **84** past hook **110** as the wheel rotates into the closed position is provided by locating the hook in recess **112** which encircles cylindrical mount **82** and extends radially outwardly in the neighborhood of stop **86**, as illustrated in Figure **3**. Hook **110** is thus axially spaced from stop **84** (toward the floor of the housing) to provide for travel of stop **84** past hook **110**.

[0036] The spring **42** is installed so as to be under constant tension and is preferably made of spring steel or stainless steel. This results in the worm gear being constantly biased towards the closed position, i.e., in the clockwise direction as viewed in either of Figures 1a or 1b, for example. As the gear is rotated under force provided by the motor through the worm (described in greater detail below), the tension on the spring increases.

[0037] The motive force of motor **34** is transferred to worm gear **40** by worm **38**. Thread **76** of the worm engages teeth **114**, which have an axial pitch and lead designed to mesh with the axial pitch and lead of the worm thread. Thus activation of motor **34** results in clockwise rotation of worm **38** (as viewed from the left in Figure 1a), which in turn causes rotation of worm gear **40** in the counterclockwise direction, as viewed in Figure 1a. Activation of motor **34** by application of appropriate electrical current can be instituted as by an appropriately wired button located for access by the driver, or by an activation circuit under remote control, etc. In the position of Figure 4, the torque on the worm wheel from the spring is about 330 Nmm, and the torque from the spring is about 380 Nmm when the worm wheel is in the position shown in Figure 5.

[0038] Rotation of worm gear **40** will eventually be halted by abutment of stop surfaces **94**, **96** when the gear has rotated through an angle of about 270° to the fully open position, as previously described. Halting the gear rotation prevents the worm from turning, and hence causes motor **34** to stall. The power supplied to the motor is cut off and the stored energy in the coiled spring causes the worm gear to rotate back to the closed position.

[0039] The worm gear **40** has a central aperture **116** which receives a shaft **44** attached to cam **28**. The cam and shaft are injected molded as a single piece of the same type of plastic as the worm gear. The exterior profile of the cross-section of shaft **44** matches the cross-section of central aperture **116** of the gear and the cross-sections are non-circular. Shaft **44** received into the aperture is thus fixed against rotation with respect to the axis of the worm gear. Installed shaft **44** is also centered on the central axis of the worm gear so that when the gear rotates about the axis so too does the cam shaft. It will further be noted that the engagement of surfaces of the shaft **44** and aperture serve to orient the cam for operation between the closed and open positions.

[0040] Cam **28** is installed as part of the device after assembly of the closure and housing, described further below. This is accomplished through tabs **150** at the free end of shaft **44**. Each tab is located at the end of finger **152**, the fingers being radially spaced apart from each other on opposite sides of the central axis of shaft **44**. Each tab includes abutment surface **154** which opposes and abuts surface **156** surrounding the central aperture of worm wheel **40**. Opposing tab surfaces **154** is surface **158** of shaft **44**, surface **158** being in abutment with surface **160** of the worm gear. Thus, for installation, cam shaft **44** is inserted through aperture **162** and into worm wheel aperture **116**. Chamfered lead surfaces **164** of the tabs abut against inner surfaces of narrowed portion **117** of aperture **116** squeezing the resilient fingers together as they pass through the narrowed passage, eventually springing apart into the installed position shown in Figure 14 in which surfaces **154**, **156** abut each other, and surfaces **158**, **160** abut each other, to affix the cam against axial movement with respect to the worm wheel.

[0041] The cross-sectional profile of the cam surface is wing-shaped. Translation of the rotational motion of the cam shaft **44** through the cam surface to move latch **22** from the closed position to the release position is illustrated in Figures 1a and 1b. As shaft **44** rotates, the cam surface area generally designated as **118** contacts latch **22**. As this rotation occurs, the radial distance (from the center of shaft **44**) of the contact portion of the cam surface with the latch is in contact increases resulting in forced movement of

the latch from the closed position towards the release position. As described above, the worm gear and affixed cam rotate until the fully open position **28a** (Figure 1b) is reached and motor **34** stalls, which stall leads to the eventual return of the cam to the closed position.

[0042] The cam profile converts the output torque to a linear force pushing against a movable lever, plate or other feature to which one desires a force to be applied. This cam functions as a further gear ratio for the system, where smaller distances pushed by the full rotation of the cam are seen to result in higher applied forces by the cam.

[0043] It is possible that the installed device could be exposed to minor amounts of water from time to time, as when a trunk was opened during a rainstorm, etc. To lessen the possibility of damage from such exposure, a liquid flow path for such liquids is provided around the periphery of the plate closure edge. Ridge **120**, molded as part of housing **30**, and ridge **122**, molded as part of the closure plate **32** are thus shaped to abut against opposing surfaces (of the closure plate and housing, respectively) to provide a limited seal against ingress of water. Further, the ridges are spaced slightly inwardly from the extreme periphery so that a liquid flow passage **124** is defined around the periphery of the ridges.

[0044] Housing **30** and closure plate **32** are conveniently assembled together during manufacture of device **20** through a single assembly screw **126** received through plate aperture **128**, the screw shaft being received into housing aperture **130**. Aperture **130** is of smaller cross-section than the shaft of the screw so that the threads of the screw become embedded in the plastic wall of the housing during assembly.

[0045] The housing and plate have a further three pairs of communicating apertures **132**, **134**, **136**. These apertures are used during installation of the device onto the automobile latch by fasteners **138**, **140**, **142**. Areas **144**, **146**, **148** of the external plate surface surrounding the apertures are in positive abutting contact with surfaces of the automobile when installed. (This could equally apply to external areas of the housing surround the apertures.) In this way, when the device is installed with the remainder of the latch, compressive

forces are further applied to the housing and closure by their being sandwiched between the heads of fasteners **138**, **140**, **142** and auto surfaces with which plate areas **144**, **146**, **148** are in positive abutting contact.

[0046] Spring **42** of the illustrated device can be omitted, which of course would free the worm wheel from biasing. In such situation, the control circuitry for the device may be modified to drive the motor in first and second directions so as to move the cam from the first to the second (nominally open to the closed) positions illustrated in Figures 1a and 1b, respectively, and to move the cam from the second to the first positions. The device could thus alternatively be used, for example, to positively move a latch between first and second positions, e.g., a lock lever may be moved between locked and unlocked positions. It will be appreciated that the cam or other output arm may have a different profile for different applications.

[0047] The illustrated embodiment has been described with particularity for the purposes of description. Those skilled in the art will appreciate that a variety of modifications may be made to the embodiment described herein without departing from the spirit of the invention.